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ABSTRACT

Expressing the need for a description of communication that is equally applicable to all the social sciences, this report develops a general model of the communication process based upon the principle of convergence as derived from basic information theory and cybernetics. It criticizes the linear, one-way models of communication that have dominated past research for failing to represent the complexity of the communication process and identifies the hidden biases of these models, especially toward individual psychology and mechanistic explanations. After discussing the advantages of a cybernetic explanation, which uses the concepts of information, feedback, networks, and purpose, the author develops a further definition of information and meaning. Finally, a paradigm of communication as a cyclical process of convergence and divergence over time is presented. (Author/MM)

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THE CONVERGENCE MODEL OF COMMUNICATION

by

D. Lawrence Kincaid

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This paper develops a general model of the communication process based upon the principle of convergence as derived from basic information theory and cybernetics. The author is critical of the linear, one-way models of communication which have dominated past research. The hidden biases of these models, especially toward individual psychology and mechanistic explanation, are identified. The advantages of cybernetic explanation are discussed in that context. Finally, the definition of information and meaning leads to a paradigm that presents communication as a cyclical process of convergence and divergence over time.

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THE CONVERGENCE MODEL OF COMMUNICATION

INTRODUCTION

Communication is widely recognized today as the fundamental social process, as the web of society. The social sciences--in fact, all of the sciences which study living systems--must deal with it at some point, but differences in the purpose, terminology, and assumptions about communication make it questionable at times whether or not the same phenomenon is being studied. There remains a wide gap between the scientific study of communication and the art of communication. It seems inevitable that the creative, artistic aspect of human communication must be abandoned when the process becomes reduced to the equivalent of sending messages over a telegraph line. Modeling communication for the purpose of scientific research always contains this risk. But is communication really so broad--or so narrow--that no adequate representation of the process can be developed which is useful for more than one purpose?

This paper develops a general model of the communication process based upon the principle of convergence as it is derived from basic information theory and cybernetics. A model is a physical or symbolic representation of concrete phenomena in abstract terms which can be applied to more than one case at more than one time. A model should contain both of the following elements: (1) a conceptualization of the phenomenon being explained, and (2) an assumed underlying causal relationship (Kinloch, 1977). Good theories, which both explain and predict phenomena, can be no better than the models upon which they are founded.

The paper is critical of the linear, one-way models of communication which have dominated past research. The hidden biases of these models are identified, especially the biases towards individual psychology and mechanistic explanation. The advantage of cybernetic explanation is discussed, from which the principle of convergence is derived. Information and meaning are defined, which leads to a model of communication as a cyclical process of convergence and divergence over time. The model itself is consistent with many of the conclusions of recent research as well

as important ideas from the past. The convergence model contributes a new paradigm for communication research, conducted within the network of human relationships which communication creates, and by which it is created.

CRITICISMS OF THE LINEAR PARADIGM

One of the earliest communication models was proposed by Aristotle, who specified the speaker, the speech, and the audience as the constituent elements of the communication act. Communication, as conceived by most people today, has been greatly influenced by the models proposed in the late 1940s by Harold Lasswell, and by Claude E. Shannon and Warren Weaver. Lasswell's (1948) basic model consisted of "who says what, in what channel, to whom, and with what effect?" The addition of the channel as a specific element was in response to the growth of new communication media. The inclusion of effects was an important break with past models which mainly served prescriptive purposes. The study of effects initiated a new field in the social sciences: the communication approach to human behavioral change.

The scientific study of communication "took off" when Shannon and Weaver set forth their model in The Mathematical Theory of Communication (1949). Communication was defined as "all the procedures by which one mind may affect another," but the model itself was designed for purposes of electronic engineering. It is essentially a linear, left-to-right, one-way transmission of messages from an information source through transmitter, signal, received signal, and receiver to its final destination. The model led to technical improvements in message transmission, and it brought together people from several disciplines to work on a common problem. The effort to create a unified model of human communication which it stimulated, failed, because the theory did not consider the semantic or the pragmatic levels of communication.

During the decade which followed the publication of Shannon and Weaver's book, three other models were developed which guided communication research during the 1960s. Wilbur Schramm (1955) described communication as an act of establishing contact between a sender and a receiver, with the help of a message, where the sender and receiver have some common experience which lends meaning to the messages encoded by the sender and decoded by the receiver. Westley and MacLean (1957) emphasized an additional element, feedback, and placed the communication act in the wider framework of an external environment. Then David Berlo (1960) developed the Source-Message-Channel-Receiver (S-M-C-R) model

of communication, in an attempt to synthesize the previously described models. The concept of feedback was added to communication models to make them more consistent with new developments in cybernetics and information theory (Wiener, 1954 and 1961) and to widen their application.

The communication models of the 1960s were especially useful for the design of experiments which assumed one-way causality, and for the study of propaganda and mass persuasion. These models describe a simple communication act, but not the process of communication.

Although Berlo defined communication in terms of process over seventeen years ago, subsequent research could not pursue this idea, in part because he moved from process to "a model of communication (S-M-C-R) which is essentially linear in form" (Smith, 1972). Berlo (1977, p. 12) recently acknowledged that "S-M-C-R was not intended as a 'model' of communication, that it met none of the tests of theoretic modelling, and that it was developed as an audio-visual aid to stimulate recall of the components of a communication relationship." The difficulty resulted from failure to recognize "the assumptions underlying linear causal determinism" (Berlo, 1977, p. 12).

The limitation of linear models became apparent in their application to the study of mass communication (Klapper, 1960; Katz and Lazarsfeld, 1955), and to the diffusion of innovations (Rogers, 1962, 1971, 1976). The basic linear paradigm was appended, but not replaced. A two-step flow hypothesis was proposed to explain why the mass media did not achieve the expected effects on political behavior (Lazarsfeld and others, 1946; Katz and Lazarsfeld, 1955, p. 132; Katz, 1957). It was soon replaced with the idea of a multistep flow (Schramm, 1973).

In 1964, Bauer pointed out the limitation of models of one-way influence for mass communication research. "The model which ought to be inferred from the data of research--is of communication as a transactional process in which two parties each expect to give and take from the deal approximately equal values" (1964, p. 319). Writing almost a decade later, Bauer rephrases his basic argument. Effective communicators must use terms relevant to their particular audience. "In other words, the audience would have influenced what he said before the audience ever heard or read what he had to say" (1973, p. 142). In spite of numerous attempts to establish a transactional model over the last twenty years, there has been "little effective impact on the organized research or systematic writing that is done" (1973, p. 143).

Epistemological Biases

The main problems with these models stem from basic epistemological assumptions about the nature of man and the nature of information, how we get it, and what sort of stuff it is. Other critics have pointed out that in our daily experience there is a tendency to treat information as if it could be carried from a source to a receiver like water in a bucket (Diaz-Bordenave, 1972), sand carried across a city in a dumptruck (Berlo, 1969), or a bullet shot from a gun at a target (Schramm, 1973).

All of these analogies of the communication process treat information as if it were purely a physical entity which could be moved around like "billiard balls" on a table. There is a physical aspect to information, and this assumption works in many situations. Nevertheless, this assumption about information contributes to another epistemological fallacy: The individual mind is an isolated entity, separate from the body, separate from other minds, and separate from the environment in which it exists (Bateson, 1972).

Treating information like a physical substance and individual minds like separate entities has contributed to the following biases in the study of human communication:

1. A view of communication as a linear, one-way act, usually vertical, rather than a cyclical, two-way process over time.
2. A source bias based on dependency rather than on the relationship of those who communicate and their fundamental interdependency.
3. A tendency to focus on the objects of communication as if they existed in a vacuum, isolated from their context.
4. A tendency to focus on the messages *per se* at the expense of silence and the punctuation and timing of messages.
5. A tendency to consider the primary purpose of communication to be persuasion rather than mutual understanding, agreement, and collective action.
6. A tendency to concentrate on the psychological effects of communication on separate individuals rather than the social effects and the relationships among individuals.
7. A belief in one-way mechanistic causation rather than mutual causation which characterizes human information systems that are fundamentally cybernetic.

These seven biases are interrelated and cumulative; each tends to support the others and to create a coherent image of the communication process, in spite of the limitations and problems that it produces. The tendency to treat communication as one-way and vertical, and to take the point of view of sources as subjects who use communication to produce a change in receivers as objects (Freire, 1973), follows quite naturally from the bias of mechanical causation.

Limits of Mechanistic Causation

The fundamental idea of causation is learned very early in childhood from the experience of willfully moving one physical object, say, a ball, with the force of another physical object, the hand (Michotte, 1963; Quine, 1973; deCharms, 1968). From this early action, we develop a concept of causation, described verbally by such expressions as "this produces that," "this is a means to that end," and "if this, then that." These early conclusions of mechanistic causation are usually quite reliable: the ball may not go where I want it to go, but if I hit it, it always goes.

Communication and information appear to work the same way at times. If the child cries loud enough, then his mother will come. But an important difference is readily apparent. The mother's reaction is not as immediate as the recoil of a physical object from the impact of another. Sometimes the mother does not come at all, no matter how loud the cry. Sometimes when she does come, she does not do what the child wants. Cries vary a great deal; sometimes it is difficult to interpret what a certain cry is related to: what it means. Information does not work like a material object.

The basic difference between mechanical effort and information makes the physical world of the child much more predictable and certain than his social world and his relationships to other human beings. As the child grows up he learns that science has developed ways to predict and control the movement of physical objects and energy with what seems like amazing accuracy and reliability.

The ideas and language of causality which the layman takes from science are based on the notion that all of the other influences in a situation can be held constant except the two that are causally related. To discover a simple causal relation, the experimental scientist attempts to hold constant all other factors which he suspects will influence the relationship he is studying. Next, by establishing several pairs of such relations, he can, presumably, combine them into a general law, or an equation, in which all contributing factors appear as variables. (Rapoport and Horvath, 1968, p. 87).

This analytical method has proven successful enough in the physical sciences, but it has also created an exaggerated and misleading concept of physical causality, especially as applied to human behavior. The mechanistic, reductionist paradigm assumes that "if we knew enough about how living beings were put together, we could write down the equations that govern behavior; and if we were clever enough in mathematics, we could solve the equations and so determine the 'trajectories' of behavior" (Rapoport, 1968, p. xv). However, the phenomena are much too complex, and the mathematics not sophisticated enough. Even in celestial mechanics, for example, "after centuries of observation and computing, the positions of the planets next year or ten years from now cannot be predicted with the accuracy desired" (Bellman, 1964, p. 198).

The epistemological assumptions underlying mechanistic explanation are too often overlooked: The effects of observation and measurement on the objects studied are negligible, and other factors can be considered equal or constant. We suppose, for example, that if a physicist knew the mass, position, and velocity of a billiard ball at a given time, he could easily predict its position at a later moment.

Brillouin (1964) uses this example to demonstrate the limits of mechanistic prediction due to the inherent imprecision of all measurement. He describes a billiard ball moving along a given direction between two rigid walls and located at a point x, where x equals 0, plus or minus one. The motion of the billiard ball would seem to be perfectly determinant, but we have to take into consideration the inherent lack of precision in measuring the initial conditions. "When we throw the ball, we know the point of departure $x = 0$ only within an error Δx and we can define the initial impulse only with Δp" (Brillouin, 1964, p. 91). According to Brillouin, the atomic physicist, Max Born, considered this simple problem and concluded that after a certain time t has passed:

> . . . we know the position of the ball with an error $\Delta x + (t/m)\Delta p$ and this may soon become larger than the distance between the walls. Henceforth we only can say that the ball is somewhere between the walls, a result which can hardly be called "determinism" (Brillouin, 1964, p. 91).

In other words, what are regarded as experimental errors cannot be made as small as the experimenter might wish, for they are part of the facts of the experiment and must be included in the theory. This eventually became necessary at the quantum level of theoretical physics where the

size of the errors relative to the phenomena studied became larger, and where it was also discovered that the process of obtaining information affected the phenomena under study.

The ideal of determinism which is so much a part of mechanistic causation is due, to a great extent, to the adherence to the belief in the concrete reality of individual, separate, and isolated entities. "Isolated material particles are abstractions, their properties being definable and observable only through their interaction with other systems" (Bohr, 1934, p. 57). Furthermore, the concept of force felt over a distance, or between particles, is no longer useful: "The forces holding particles together are themselves particles exchanged in the cross channels" (Capra, 1975, p. 297).

Every particle consists of all other particles. This is the essence of the new "bootstrap" models which are being developed to describe subatomic hadrons. "Each hadron is held together by forces associated with the exchange of other hadrons in the cross channel, each of which is, in turn held together by forces to which the first hadron makes a contribution" (Capra, 1975, p. 296). The whole set of hadrons is, in a sense, self-generating, and by means of mutually shared and exchanged particles it pulls itself up by its own bootstraps. According to this new world view, the universe is a dynamic web of interrelated events: "None of the properties of any part of this web is fundamental; they all follow from the properties of the other parts, and the overall consistency of their mutual interrelations determines the structure of the entire web" (Capra, 1975, p. 286).

If it is necessary for social scientists to borrow analytical concepts from the physical scientists to explain human communication, what could be more appropriate than the concepts of interaction, self-generation, mutual exchange, and sharing? In fact, the analogy of the "bootstrap" and the "dynamic web" of interaction applies to human communication so well that it would seem contemporary physicists are borrowing from the social scientists to explain their work rather than the contrary.

CYBERNETIC EXPLANATION AND CONVERGENCE

In the twentieth century the most dramatic improvements in the prediction and control of objects and events came not from physics per se, but rather from the new sciences of information and cybernetics. The most successful applications of the cybernetics paradigm thus far have

been to the design of new information technology, such as computers or cruise missiles, rather than the improvement of our understanding of human communication.

The initial attempts to apply cybernetics to human communication were not very successful because of the reliance upon man-machine, man-nature, or machine-machine analogies and illustrations. Most discussions of cybernetics begin with self-regulating, thermostat-furnace systems (Boulding, 1968, p. 7); thermostats, automatic pilots, or bicycle riders (Ashby, 1956, 1968, p. 298); or an individual driving a nail with a hammer (Miller, Galanter, and Pribram, 1960; 1968). Bateson (1972) makes the most insightful application of cybernetic explanation to human systems, but even he often resorts to man-environment systems (or circuits) to illustrate the basic principles of information. The man-environment system of interaction is important, but it should be remembered that man's interaction with his environment is mediated by symbols and concepts shared with other human beings who live primarily in a symbolic environment of their own creation (Rapoport, 1974).

Cybernetics

What are the important elements of cybernetic explanation, and how should they be applied to human communication? The four most important elements of cybernetic explanation are the concepts of information, feedback, networks, and purpose. They have been as useful for explanation at the level of molecular biology as for the design of electronic computers. In this section we apply these building blocks to the explanation of human communication.

Bateson (1972, p. 459) in Steps to an Ecology of Mind, states that "if you want to explain or understand anything in human behavior, you are always dealing with total circuits . . . The elementary cybernetic system with its messages in circuit is, in fact, the simplest unit of mind; and the transform of a difference [information] traveling in a circuit is the elementary idea." In order to understand any system, the boundaries must be determined in such a way that none of these circuits of information exchange is cut off in ways that leave things inexplicable.

A system is a set of interrelated parts coordinated to accomplish a set of goals (Churchman, 1968). Human systems are connected and coordinated, not by mechanical means nor by the force of matter and energy, but rather by the exchange of information. This does not mean, however, that the physical effects of, say, an earthquake can be ignored

by those who study communication. It merely means that we are more interested in what happens among people when they perceive and interpret information about an earthquake. Information has a physical reality, but it is always about something else.

The most important characteristic of the information sharing process is the communication circuit, or network of circuits, by which individuals within the system are interconnected. A circuit is not a one-way link; it is a circular loop, with the capacity for a two-way exchange of information. The two-way exchange of information is a prerequisite for feedback. No human system can function properly--can be coordinated to accomplish a set of goals--without feedback. Feedback "produces action in response to an input of information and includes the results of its own action in the new information by which it modifies its subsequent behavior" (Deutsch, 1968, p. 390).

In the social sciences the concept of feedback has been interpreted more generally to mean "knowledge of results." It is most commonly used as if only two steps were required: information out and information back in. These two steps are the necessary requirements for feedback, but one such cycle is rarely sufficient for most systems to function properly. Determination of the direction of movement in the relative position of two objects requires a minimum of at least two complete feedback cycles. Thinking of feedback as merely the second step of one cycle automatically puts the emphasis on one as determining the position of the other rather than on the relative movement of the other over time or on the change in their mutual relationship.

When feedback is considered only as the second part of one information cycle, it is natural to think of it as an object, or noun, rather than as a process over time. When several cycles of information exchange are used to coordinate the relative movement (change) of two or more persons, then feedback becomes a process, and not just knowledge held at one point in time.

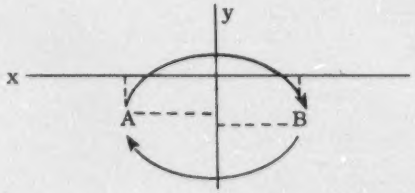

FIGURE 1.
One-Cycle Feedback Determines Relative Position

This fundamental distinction is displayed graphically in Figure 1. Although most issues or topics of discussion are multidimensional, for purposes of illustration it is convenient to use two axes, x and y, which would correspond to the two main dimensions of an issue. In the discussion that follows, the graphic positions of A and B on the x and y axes should be treated as relative positions on an issue such as human rights or the women's movement. In the human rights controversy, for example, there are at least two distinct dimensions: individual freedom (x) and national self-determination (y). In discussions of the women's movement, a dimension of equal opportunity (x) and a dimension of equal behavior (y) can be identified. Two persons, A and B, may agree in principle that men and women should have equal opportunity for work and pay, but have extremely different positions as to whether men and women should behave the same way on the job. Communication is the process by which two or more persons come to an understanding regarding their relative positions on such issues.

As Figure 1 shows, one cycle of feedback, as described in most models of communication, is only sufficient for A and B to determine their relative position at one point in time. But even this simple level of description is misleading when it is presented with the source bias of one-way, linear models of communication. A supposedly sends a message to B, and then collects "feedback" information from B to see what the effect of his message has been. The effect of his message is supposed to be the position of B on some dimension(s) of attitude, value, belief, and so forth. But there is no such thing as absolute position irrespective of the position of others or one's own position at different points in time.

One cycle of feedback lets A determine the position of B relative to A's own position, relative to the ideal position or goal of A, or, if B is an aggregate of people, relative to all other Bs. The idea that B's position is always relative to A's position should make it obvious that one cycle of communication also allows B to determine the announced position of A with respect to himself. In summary, one cycle of feedback is sufficient only to determine the mutual or relative positions of A and B. It is impossible to make a valid assessment of the effect of A's message on B (or vice versa) without knowing the direction and rate of change in B's position before and after he receives A's message.

Two cycles of information exchange are sufficient to determine the direction and velocity, or the rate of change in A's and B's relative positions. The path of movement is shown in Figure 2 as a dashed line passing through each one's positions at different points in time. This change may

be computed as the difference of position in proportion to (or first derivative of) the difference in time (velocity = dl/dt). With two complete cycles of information exchange, both A and B can determine the direction and rate of change of each other.

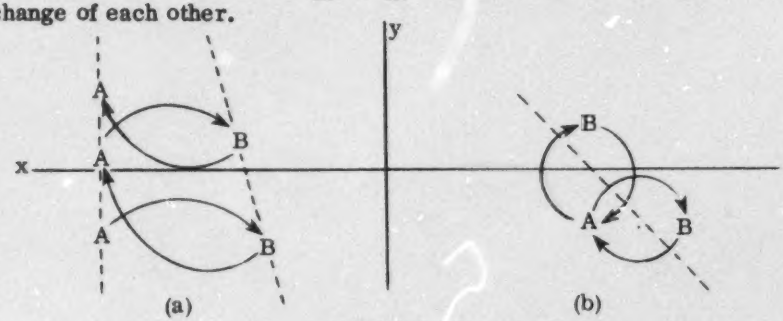

FIGURE 2.
Two-Cycle Feedback Determines Direction and Velocity

In example (a), we see that A is moving perpendicular to the arbitrary x axis and parallel to the y axis. B is moving at the same rate of change as A, but at an angle to A's path and the arbitrary y axis. This makes B look like he is converging towards A, who does not seem to be shifting at all towards B. This impression, of course, is due entirely to the arbitrary nature of the x and y axes. If we remove the two axes, shift the page slightly or simply drop a new axis which is always equidistant from A's and B's paths, then it would seem as if they were converging towards one another at an equal angle and at an equal rate of change.

In example (b), we have fixed A's position in the two dimensions shown, and have shown B's position changing relative to A's over two cycles of information exchange. With just two cycles and two points to determine B's position it appears as if he might continue moving at a constant rate of change well past A's position.

Example (a) in Figure 3 shows how misleading two cycles of feedback may be. Once again A's position has been arbitrarily fixed with respect to the x and y axes. But after plotting B's position over four cycles of feedback, it now appears as if his position were gradually converging towards A's position. Once again, the arbitrary x and y axes make it seem as if A's position were fixed at the center, and that only B's position is moving. If the axes are removed, then there is only movement of A and B relative to one another, and A and B may both be converging towards one another at the same rate and angle.

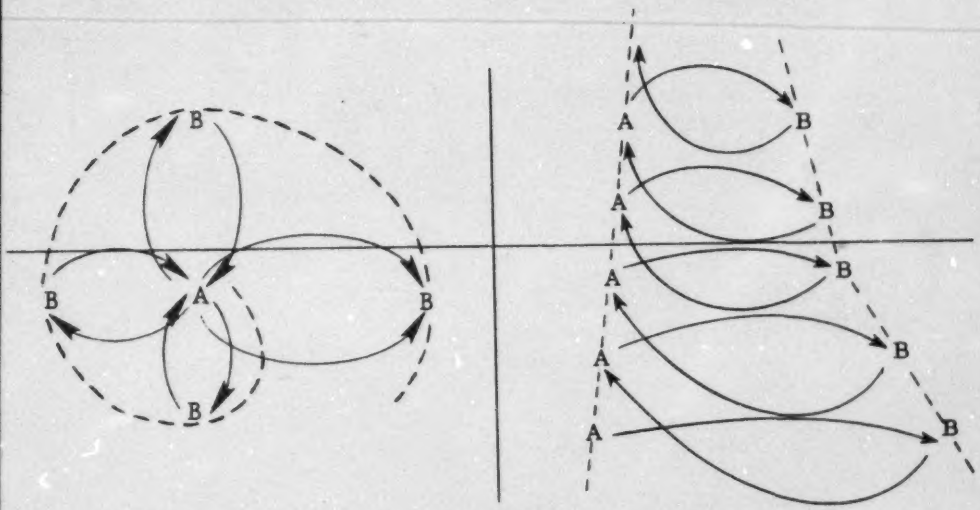

FIGURE 3.
Three-Cycle Feedback Determines Change in Direction and Velocity and Four-Cycle Feedback Determines Change in Acceleration

Figure 3 shows how additional information may be derived from three or more cycles of information exchange. Three cycles of feedback are sufficient to determine the change in direction and rate of change of B's and A's relative positions. This can be graphically displayed as the angle formed by their lines of movement from time one to time two, and from time two to time three. Three cycles of feedback also allow us to calculate changes in velocity as another proportion of differences, or second derivative (acceleration = d^2l/dt^2).

By moving to a third level of differences in our analysis, we reveal in the clearest form possible the critical difference between classical mechanics and cybernetics. In classical mechanics, predicting acceleration, or change in the velocity of a moving body, can be done entirely in terms of the distance between the mass of the moving bodies themselves. No variables outside of this mechanical system are required, and the influence of the outside observer can be considered negligible compared to forces within the system. To change the rate of acceleration of a falling body in space, however, requires the action or interference of some "free" agent outside of this system. It is assumed that there could be no prediction if a free agent were admitted into the system, and that the equations would not apply or would be too complicated.

> However . . . there is a formal expression which covers the "free agent," namely, the third derivative [d^3l/dt^3] . . .

it means that freedom (unpredictability) is part of the system. In certain cases, prediction is theoretically possible, as in the case of feedback wherein a predetermined position regulates control (Young, 1976, pp. 17-18).

Aeronautical engineers, however, have to deal with the third derivative, d^3l/dt^3, or rate of change of acceleration. They call it "jerk," because when the acceleration is changed in an airplane, "it does so in an all or nothing fashion which results in a jerk" (Young, 1976, p. 15). Airplanes, of course, are acted upon by free agents, and they do defy the law of gravity. More accurately, the pilot of an airplane (or his automatic pilot) is a free agent outside the equations of classical mechanics, with his own purposes. One of his purposes, naturally, is to avoid the force of gravity, to control, the tendency of gravity to accelerate his plane towards the earth. Control is a more general name for the phenomenon of "jerk," which applies to the control over the changes in the direction and the rate of acceleration. We exercise such control in a car by using the accelerator, the brakes, and the steering wheel. The changes created by a "free agent" require information and control, or more precisely, guidance, which implies purpose.

We have arbitrarily drawn movement in the relative positions of A and B in Figure 3(b) so that A's direction and rate of change would appear constant with respect to the two-dimensional axis of the figure. B's direction and rate of change appear to vary during this span of time. His position appears to accelerate and then to deaccelerate relative to itself or the two-dimensional axis of the figure. And finally, their changes over time relative to one another would suggest that their positions are converging, and will continue to converge unless one or both receive new information from some "free" agent, including each other.

As we have shown earlier, both A and B are themselves free agents with respect to their own history and past information sharing. Either one is capable of creating new information (on purpose or accidentally) which could affect not only their future direction and rates of change relative to one another, but could also allow them to reassess their past positions. It may seem like the reorientation of history would occur only in memory and would therefore be trivial. It is not. As the whole analysis shows, each one's assessment of where he and the other are moving depends upon his record or memory of past positions. New information can cast doubt and change where each one thought the other was in the past. The Watergate scandal in American politics is a classic example of a rapid change in the position of the public and its leader once new information forced a reevaluation of all previous cycles of communication.

Careful analysis of the five-cycle feedback process, however, reveals the critical difference between man-machine systems, like cars and airplanes, and interpersonal communication systems. In human communication we must account for systems in which both persons, and perhaps others, are free agents, in the sense just described. The four-cycle feedback case shows the movement of both A and B relative to one another over multiple time intervals in which each is making decisions based on information from the other person and from himself about their relative change in positions over time. Communication is thus a multistage information and decision process (Bellman, 1964) in which all participants may change relative to one another over time, and in which all participants create and share information which can affect their relative movement. Each stage, or cycle, in the process is contingent upon the previous one.

The Principle of Convergence

To avoid the current confusion and ambiguity caused by using the term feedback for only one information cycle, we must find a new set of terms in which the nature of feedback as a process is retained. We can find the appropriate terms by observing what happens when the process of feedback over several time intervals is effective or ineffective.

When the process of feedback is observed over more than one cycle and it is effective, the result may be described as "a series of diminishing mistakes--a dwindling series of under-and-over corrections converging on the goal" (Deutsch, 1968, p. 390). An effective feedback process creates convergence. When feedback is not adequate, "the mistakes may become greater; the network may be 'hunting' over a cyclical or widening range of tentative and 'incorrect' responses ending in a breakdown . . ." (Deutsch, 1968, p. 390). Thus, an ineffective feedback process creates divergence.

Strictly speaking, the term "feedback" only refers to one-half of one cycle of information exchange. This is why it was relatively easy to add feedback to the linear, one-way models of communication described above. Nevertheless, to understand human communication as a process requires the analysis of a series of such cycles of information exchange over time. Convergence and divergence are the most useful terms for describing what actually occurs during this process. Convergence is a tendency to move toward one point or toward one another, to come together and unite in a common interest or focus. Divergence is simply moving away or apart. Both terms, as they are commonly defined, are easily applied to human communication, even in its most general sense as the fundamental social process.

For many years now communication scholars have been defining communication as a dynamic process while continuing to use static terms and concepts to describe it. More dynamic models have been called for, but their development has been impeded by the shortcomings of the language of communication. Convergence and divergence overcome this basic obstacle. These terms can refer to nothing but process: change conceived as a movement toward or away from some point, focus, common interest, or other persons.

Convergence implies movement, and it always implies the possibility of its opposite, divergence. Convergence and divergence may even occur simultaneously, depending upon the points of reference used. A person or group whose position is converging towards another may at the same time be diverging away from that of some third person or group. Therefore, neither convergence nor divergence can be used without implying the possibility of movement in the other direction.

The second important feature of the principle of convergence is that it implies that a purpose or goal already exists once a network or circuit of information exchange has physically come into existence (Deutsch, 1968, p. 391). Correction of one's course of action can be done only with respect to a desired direction, goal, or purpose. Feedback is negative or positive only with respect to a predetermined goal. Convergence or divergence describes a change in position only with respect to some predetermined reference point(s), desired direction, or goal.

Is it possible to identify a fundamental purpose of all communication which exists prior to the establishment of the circuit of information exchange? Deciding upon personal or collective purpose is one of the more time consuming activities of human systems. Communication is used for the creation and selection of most human purposes. But if communication is used to create and determine a purpose, then what is the primary purpose that exists prior to the formation of all information circuits? The fundamental purpose of human communication is to define and to understand reality in order that other purposes can be selected and achieved. Thus, understanding and mutual understanding are fundamental to the process of communication itself. The achievement of other purposes depends upon them.

The greatest difference between explanation in the physical sciences and the social sciences is that the "objects" of study--unlike billiard balls--have purposes or goals of their own. Communication cannot be adequately studied without reference to human purpose and

values. Cybernetic explanation is teleological rather than mechanistic. Unlike man-machine and machine-machine systems, however, most of the goals of human systems are not given, externally imposed, or built into the mechanism. They are self-generated in and by a social system, in "bootstrap" fashion, through a process of mutual interaction and exchange of information.

Human systems of communication are comprised of a network of individuals and groups who share information over time and converge or diverge away from one another in terms of their mutual understanding of reality. By reality, we do not mean physical reality per se, to which we have no direct access, but rather the symbolic representation of that reality. Man's interaction with his environment is mediated by symbolic information, much of which refers not to physical reality but to other sets of signs or symbols. Therefore, an adequate, mutual understanding of the symbolic information which is shared to define reality is a prerequisite for any other social or collective activity. Convergence and divergence take place within multiple circuits or networks, of information exchange which are established and maintained by the process of sharing information.

Information

It is difficult to describe communication without some reference to information or one of its synonyms. We have already found it necessary to use information to define communication networks and the principles of convergence. In fact, both network and convergence may be derived from the basic concept of information. Information has become the fundamental concept for the study of all living systems.

What is information, and what makes it so important for the study of human communication? There has been a trend recently to define information in an impressive but over-simplified way as that which reduces a receiver's uncertainty in a given situation. This definition is sound, but incomplete and misleading. It does not do justice to the richness of the concept and its relationship to other important concepts developed to clarify the same phenomenon. Furthermore, the lopsided emphasis on the reduction of uncertainty obscures the creative aspects of information processing and the other changes which it can create.

Information--and its convergence function in human communication--may be defined with reference to four interrelated terms: form, difference, invariance, and uncertainty. The meaning of each of these terms is dependent upon its opposite: substance, similarity, variance, and certainty.

It is the differences between each of these opposing terms which gives meaning to the concept of information in human communication.

It is, of course, no accident that "inform" is comprised of "form" plus the prefix, "in." The Latin word, forma, means contour, figure, shape, model, or pattern. Pattern has become a more general concept than form, but it tends to obscure the classic relationship between form and substance. A dictionary makes this clear: form is shape or structure as distinguished from material. Form is the arrangement of matter and energy. Although it must be distinguished from physical substance, form is made possible by the arrangement of that substance.* Sub·stance literally "stands under" form at a lower level of abstraction. Substance is the "ultimate reality" which underlies form, the outward manifestation of change.**

Bateson (1972, p. xxiii) traces this fundamental distinction back to the central origin myth of Judaeo-Christian thought found in the Old Testament:

> In the beginning God created the heaven and the earth.
> And the earth was without form, and void; and darkness
> was upon the face of the deep.

The next passages add light, the division of light from darkness, followed by the naming of the light, Day, and the darkness, Night. The origin of matter is dismissed in this myth; the origin of order or form is described at length.

Substance and form become two distinct problems, a separation of which is still maintained in modern science. Laws for the conservation of matter and energy are still separate from the laws of order, negative entropy, and information. Order is seen as a process of division and selection based upon a "difference which shall cause some other difference at a later time" (Bateson, 1972, p. xxiv). Naming is closely linked to, if not inseparable from, the act of dividing and classifying according to form.

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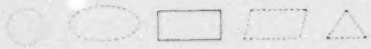
*This distinction, of course, is purely conceptual. In another sense, substance and its form are one and the same, inseparable and nonexistent without one another.

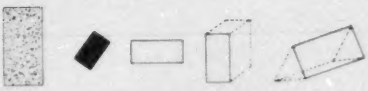
**In most communication models, substance is the medium of exchange, commonly described--quite metaphorically--as if it "carries" or "conveys" information the way a truck carries sand.

The perception of form depends upon difference, the distinctive arrangement of matter. A specific form is just one of the different modes of existence or manifestations of the same substance. Thus, variety is a prerequisite for form, order, or structure. It makes no sense to talk about a certain form outside the context of other forms that could have occurred. To be perceived, a certain form must be recognizably different from other possible forms. Information is simply "a difference which makes a difference," and communication is the transform of such a difference through a complete information circuit (Bateson, 1972).

It is more accurate to say that we scan an object or medium and search for form, rather than receive form in a passive sense as if it came to us. As a transitive verb, form means to give something a particular shape, to mold it into a certain state. The observer of an object has a variety of forms in mind which he actively projects onto the object to see how well each fits. The form must be invariant over time and distance. A mirror is a more efficient, or invariant, medium for reflecting the form of one's face than the surface of a pond or stream. A physical substance which varies too rapidly over time or space makes the perception of form difficult, if not impossible.

A few examples will demonstrate the relationship between difference and information, and will introduce the related concepts of approximation, tolerance, and convention. In set A of Figure 4 we have created information by giving a certain, distinctive form to the page with our pen out of a variety of other possible forms. To recognize the particular pattern named "rectangle," one of the forms has to be different enough from the other possible forms to be distinguished. There must also be something constant, or invariant, about all other shapes to which we apply the name "rectangle."

Set A: 

Set B: 

Set C: form of information or views. One must recognize Chuang Tzu brings out is precisely the point that there are

Set D: form of information or views. One must recognize Chuang Tzu brings out is precisely the point that there are

FIGURE 4.
Information as Form, Difference, and Invariance

It should also be apparent from our freehand drawing that a rectangular shape does not have to be precisely drawn in order to meet the conventional standards of most people. The form can approximate a rectangle within some degree of tolerance. Approximation and tolerance are important to all information processing and human communication. Degree of tolerance immediately places information processing within the context of two or more persons rather than just one. The form and term, "rectangle," are applied by convention, according to the standards or rules of the group or subgroups who create rectangles and use the word to refer to it. The degree of approximation and tolerance varies from group to group according to the purpose in using rectangles. The architect is much more tolerant of the artist who sketches a drawing of his house than he is of the draftsman who draws the blueprints with precision instruments.

The most remarkable feature of vision is the ability to recognize an outline drawing. The eye is especially sensitive to contrast between two adjacent regions of different light intensity or color. Some three-quarters of the fibers in the optic nerve respond only to the flashing "on" of illumination. In fact, a constant visual stimulus reduces its ability to receive and transmit. The fundamental principle of information is variation, change, contrast, or simply difference, and the ability of our sense organs to perceive it. Thus, the most intense sense impressions of the eye are at the boundaries, and "every visual image in fact has something of the nature of a line drawing" (Wiener, 1961, p. 136).

Although we see and talk about the boundary line between two adjacent regions, in reality there is only one region with different levels of light intensity, density, shade, or color. If the contrast across the region is great enough we are able to see the boundary line and distinguish between two "separate" regions. The difference itself--the information--cannot be localized (Bateson, 1972). It is not on one side or the other, nor in the space between them. The difference is at a higher level of abstraction: the perceived relationship between one side and the other. Therefore, the difference can be in more than one place at once, or no place at all. I can see the difference at the same time you see it, or someone else, or any number of people. The same difference can be transformed into a television image (medium) and shared by millions of people at the same time throughout the world.

The fundamental properties of information apply even at the most elementary level of living organisms. Metabolism and growth, for example, require thousands of chemical reactions in order for the essential components of cells to be elaborated and reproduced. The molecular interactions

which ensure the transmission and interpretation of chemical signals in living organisms depend upon special "regulatory" enzyme-proteins which have discriminatory stereospecific recognition properties, an "ability to 'recognize' other molecules (including other proteins) by their shape, this shape being determined by their molecular structure . . . At work here is, quite literally, a microscopic discriminative (if not 'cognitive') faculty" (Monod, 1971, p. 46). This "selective theory" of microbiology can account for purposeful structure; it is derived from the primary property of nature, invariance. The phenomena of choice, elective discrimination, characterize all living beings and make them appear to escape the fate spelled out by the second law of thermodynamics (Monod, 1971, p. 59).

The perception of shape requires the discrimination of differences and the recognition of similarity. To be perceived as such, a rectangle must be recognized throughout numerous transformations of size, shade, color, and orientation. The basic "rectangleness" in Set B of Figure 4, for example, must be invariant across the other variations which occur. To read the handwriting in Set C of Figure 4, the shape of the letters must be sufficiently invariant with respect to their conventional form, or else recognition is impossible. Set D satisfies the requirement of invariance which Set C fails to meet.

To recognize the same form across a variety of transformations, we tend to bring the object of our attention into a standard position and orientation, so that our visual image varies within as small a range as possible. The form is then compared to a standard or ideal form which has been learned from experience and can be recalled from memory. If the form of the object we are observing approximates this standard form, then it is recognized as such, and the conventional name may be applied to it.

An outline drawing, especially a caricature drawing of a man's face, usually has very little resemblance to the actual face in terms of size, color, shading, depth, and so forth. Yet, it may be the most quickly recognized portrait of its subject. The most important similarity must be present, the similarity which makes the most difference in the recognition of the man's face and character. This similarity is based upon a relationship among parts.

The recognition of a person's face in a caricature line drawing depends on the relative proportion of its parts, its internal structure. Ears, nose, eyes, mouth, and so forth must maintain (remain invariant) a certain position, distance, and size relative to each other. As we shall demonstrate

below, the interpretation or meaning of all information depends upon this principle of the relationship of parts to each other, and the relationship of parts to the whole context in which they are imbedded. Proportion is one of the ways to describe the relationship among parts. Proportion is dependent upon parts, but it is a characteristic of whole structures and exists in the mind of the observer at a higher level of abstraction. This principle of proportion applies to the symbolic abstraction of language as well as the more concrete shapes of geometric patterns.

To be interpreted as a rectangle a geometric shape must have the length of its sides and the angles of intersection in the proper proportion, that is, in approximately the same proportions as the ideal standard which we project onto it. Side a in the observed object must maintain roughly the same relationship to side b as side a' does to side b' in our ideal, standard form. This comparison may be stated in the conventional form for proportion and analogy: $a/b = c/d$, $a:b::c:d$, or a is to b as c is to d. Analogy, of course, is the basic symbolic process of metaphor, the application of a symbol to a new situation where some image, form, or aspect of its meaning remains invariant.

What has been said thus far about visually processed information applies to all other senses. The sounds of language, for example, do not acquire meaning because of some essential quality, but by means of a series of functional distinctions. "Dog" can be pronounced in various ways--within some range of tolerance--as long as enough difference is maintained from "dag," "gog," "tog," and so forth. When it is heard, it must be similar enough to the conventional standard, or ideal sound for "dog" that a member of that language community can interpret it correctly. "Noises that we make have no significance by themselves; they become elements of a language only by virtue of the systematic differences among them, and these elements signify only through their relations with one another in the complex symbolic system we call a language" (Culler, 1977, p. 99, emphasis added).

When the requisite relationships hold among the parts, the basic requirement for information has been met. If, from a part of an object or sequence of events, a person can make better than random guesses at other parts of the object or sequence, then that part contains information about the remainder, and the object or sequence as a whole contains redundancy (Bateson, 1970, p. 62). The process of distinguishing one part from another part, and the whole from the parts, is necessary for the understanding of symbolic language. Language, and information in general, functions much like the "bootstrap" phenomenon described above.

Symbolic language is self-generated by means of the mutual relationship among its parts.

Meaning

By means of a simple example we can demonstrate the basic principles of information discussed thus far, and also show their relationship to uncertainty, decision, meaning, and the principle of convergence. Although a written, verbal symbol is used, other types of information--audio, tactile; verbal or nonverbal--could be used to demonstrate the same principles.

To create meaning for the following combination of letters, R-E-B-E-L-L-I-O-N, first requires that some physical substance or medium be modified such that the desired form can be distinguished from other possible forms and from the background or context of the medium itself, the blank page. This is a difference-creating process which cannot be accomplished without some expenditure of energy (i.e., action). The geometric pattern of the letters must approximate the conventional form within the requisite range of tolerance if it is to be shared with others and understood. This is creation of information at the physical level of reality. What we recognize as the word "rebellion" is not due merely to the collection of these nine letters, but rather to the relationship that exists among the parts.

Each pattern--letters or the whole word--represents an alternative choice or selection out of a larger set of related but different patterns, in this case the English alphabet and language system. The occurrence of each letter can be expressed as a probability in which freedom to vary depends upon the previous letter or surrounding letters. The ordered relationship among the letters affects the probability of occurrence of each letter, and reduces the uncertainty that a particular letter will occur out of the set of all possible letters. This principle allows us to guess some of the handwritten letters in Set C of Figure 4. Our uncertainty, in the psychological sense, is increased by the creation and perception of differences, which in our example take the form of the word, "rebellion." Our uncertainty in this situation is reduced by comparing how similar the pattern is to some conventional word pattern from our memory and then deciding whether or not it applies. It is meaningless to talk about the reduction of uncertainty without regard for the creation or increase of uncertainty.

The creation of information as a difference in a material substance or in a sequence of events takes place at the physical level of reality. The

awareness of differences in physical reality through one's senses is a perceptual process. The recognition of similarity, the projection of a standard form onto a perceived pattern, is an interpretive process, a process of pattern recognition which can now be performed by computer technology. In most discussions of communication these three processes are not adequately distinguished. The creation of information occurs at the physical level of reality, interpretation at the psychological level of reality, and perception bridges or intervenes between the physical and psychological levels of reality.

The interpretation of a word pattern like, "rebellion," is only the beginning. The semantic understanding of a word takes place at yet a higher level of psychological abstraction, and is not as simple as deciding which conventional word pattern most closely resembles a perceived physical pattern. The outstanding characteristic of a word is the wide variety of meaning which it can elicit. The semantic flexibility of word symbols is so great that it is not uncommon to find one used occasionally to mean exactly the opposite of its conventional meaning. The conceptual meaning of a word is also a potential source of uncertainty.

The semantic understanding of a word requires the application of a particular concept out of the possible set of concepts one has available to apply in a given situation. This is also a decision process which reduces uncertainty within some range of tolerance. At this level, however, uncertainty is created by recognition of the word pattern. Furthermore, there is no single concept which applies to the word, "rebellion," in the same way that there is only one word in the English language which applies to the particular combination of letters, r-e-b-e-l-l-i-o-n.

It is useful to think of the concept of a word as embedded within a relatively bound semantic space, or domain of meaning. A word like, "rebellion," has no singular, isolated conceptual meaning by itself, but rather is located or placed within an appropriate semantic space in relation to all of the other salient concepts with which it is commonly associated. Its specific meaning is a function of its relationship to other relevant concepts in a particular context. How a word is used in a particular social situation will determine its relationship to other relevant concepts, where it fits into a region of meaning.

Obviously we use word symbols to identify and to share concepts. Nevertheless, a word is not a concept. We may think with words, but the conceptual meaning of a word is much greater than the word itself. Some concepts require more than one word: "fetching water," "kickoff return," "shooting the rapids." Each of these concepts is greater than the sum of

the words selected. A "kickoff" with a "return" does not mean the same thing as a "kickoff return." "Shooting" plus "rapids" does not add up to "shooting the rapids." The same principle of meaning applies to single word concepts. There is no one-to-one ratio of conceptual meaning for each word (Terwilliger, 1968), nor a relationship of identity between word and object (Quine, 1960).

This is a contextual approach to meaning as opposed to the more common referential approach to meaning. The former received its greatest impetus from the philosophical work of Wittgenstein (1958). The work of Ogden and Richards (1927) is representative of the latter approach, especially their well-known symbol-thought-referent "triangle of reference." Even in those cases where a word may have an obvious physical referent, such a referent falls far short of our meaning for the word. The word, "table," for example, has little meaning by itself, independent of its relationship to chair, sitting, eating, or writing. The word is given meaning by the way it is used in a specific context. This is the only way to account for the initially metaphoric use of "table" as a transitive verb in the sentence, "Let's table the motion until the next session," and for semantic change in general.

"Rebellion" has a variety of possible meanings depending upon the context of other words in which it is embedded, and upon the social situation in which it is used. The conceptual meaning of "rebellion" is shared with the following set of other words: fight, struggle, disobedience, insurrection, insubordination, revolt, mutiny, revolution, war, demonstration, peaceful, bloodshed, injustice, freedom, equality, disrespect, hate, good, bad, active, passive, weak, strong, people, soldiers, children, teenagers, students, and so forth. Anytime the word, "rebellion," is encountered it must be placed in relationship to the conceptual meaning of these words and many more before it can be adequately understood. Uncertainty regarding its meaning is reduced by its placement within an appropriate semantic space. This implies that the process of understanding would be terminated when some acceptable level of tolerance has been reached. On the other hand, the process of understanding can go on indefinitely, or intermittently over a long period of time.

Bertrand Russell once said that "it would be absolutely fatal if people meant the same thing by their words." Turning this around, Hacking (1975, p. 173) remarks somewhat facetiously that "communication gets along because we do not mean the same things by our words!" Variety of meaning is a necessary principle of human communication. Communication is made possible because of difference in meaning. It reduces this difference

for some purpose to some level of tolerance over an interval of time. Sustained collective action among people requires continual communication over time to maintain a requisite level of convergence.

Placing the conceptual meaning of a word within an appropriate semantic space is facilitated by understanding the wider context of information in which it is used, in a part-whole sense. The word rebellion acquires more meaning in the context of the following quotation:

> What country before ever existed a century and a half without a rebellion? The tree of liberty must be refreshed from time to time with the blood of patriots and tyrants. It is its natural manure.

The use of the word "rebellion" in this context eliminates many of the conceptual associations listed above, and makes others more salient. The author chose to use the word in a particular sense. He also chose a place, a time, a specific medium, and a particular person with whom to share it. During the process of communication, information about this wider social, temporal context is available to anyone who attempts to understand it.

Thomas Jefferson expressed these thoughts in a letter to William Stevens on November 13, 1787. The same statement made at a political rally in 1771 in a highly emotional tone of voice would not mean the same thing as it did later in a personal letter. Nevertheless, the attempt to understand what the statement "really" meant has continued ever since it was delivered. A recent reference appeared in Gore Vidal's novel about Aaron Burr, where an older and more conservative Jefferson is quoted as saying, "I meant only that we should congratulate ourselves that in two hundred years we have had only one such internal uprising. It is a tribute to our sense of justice that redress comes before rebellion."

A word or statement cannot be separated from its context if it is to be correctly understood. Message and context stand in a part-whole relationship. It is from this part-whole relationship that meaning is derived. The information which is to be interpreted and understood consists of source, message, channel, receiver and remaining context as an integral whole. McLuhan (1964) fell short of the mark with his well-known aphorism, "the medium is the message." The source, the receiver, the whole context are also the message.

Jefferson's statement also demonstrates how new meaning for a word can be created by means of the metaphor, a special form of analogy.

Manure is to a tree as the blood of rebellion is to liberty, and by association each relationship is natural. A new distinction (difference) in the meaning of the word "rebellion" is created, based on the functional similarity (along one dimension) between manure and the blood of rebellion. The essential feature of any metaphor is that " . . . the figurative meaning carried by it must be inferred by the exercise of the imagination since it cannot be looked up in a dictionary" (Rapoport, 1975, p. 141).

The meaning for a word changes when it is used in different ways, in new contexts, in association with different words, and when it is applied to a new object or event in the physical world. The use and meaning of the word "rebellion" has changed greatly since the time when Jefferson used it. A movie like Rebel Without a Cause, which starred James Dean, helped create a new concept of youth in rebellion against society. Is this the same type of rebellion which Jefferson wrote about? Does it replenish the "tree of liberty?" Other words can be applied to the same set of actions: criminality, juvenile delinquency, social deviance, political crime, or neglected youth. The most important principle here is that whatever action, object, or situation to which a word is applied will affect the meaning of that word. The words we use to interpret any action, object, or situation will in turn affect how we will act.

Toulmin emphasizes this same principle of meaning in his discussion of science and the law. If the young scientist only learns the words and equations of his science, he may remain "trapped in its linguistic superstructure; we come to understand the scientific significance of those words and equations, only when we learn their application" (1972, p. 161). In legal jurisprudence, formal definitions are a necessary starting point, but always insufficient. The legal significance of a term develops progressively over the "succession of new situations in which the concept has been applied, and the manner in which this changing application has reflected back on its original significance" (1972, p. 161). In science, law, and culture in general, concepts acquire meaning by serving relevant human purposes in actual, practical cases.

Belief

The uncertainty of meaning and its potential for change lead quite naturally to the question of belief. It is one thing to create new meaning for words, quite another to have those meanings accepted as valid by others. Does the incident which Jefferson discussed in his letter to Stevens really constitute a "rebellion?" Perhaps it was "really" only a case of "rowdyism" which got out of hand, "peaceful protest" provoked into violence, or even

the first stage of a planned "revolution." Words, after all, are just words, regardless of the meaning upon which we may eventually agree. To determine the truth value of any word which is used requires projection of that word from a medium of exchange onto an external domain.

The question of truth arises when words are used in propositions, such as "it is a rebellion." A truth value may vary from 0 (false) to 1 (true), with intermediate levels of probability and uncertainty in between. The probabilities associated with a proposition may be based on empirical frequencies of past occurrence, or on some notion of subjective probability and uncertainty. A truth value of a proposition, however, cannot be adequately assigned and accepted by two or more individuals until some appropriate level of mutual understanding of its meaning has been reached.

Meaning and truth are bound to one another through the application of concepts to actual cases. Truth refers to the valid application of concepts, but truth cannot exceed the boundaries of understanding except, perhaps, through faith or intuition. One aspect of this understanding is the acceptance of the empirical conditions under which a given concept or proposition applies. Many disagreements about the truth of a proposition can be traced to misunderstandings or a lack of mutual acceptance of the conditions in which the terms apply. In a sense, it is meaningless to say "this" is true, or "that" is false without regard to the conditions in the real world to which "this" and "that" apply. It would be more useful to say "this" or "that" applies in a specified case or situation under certain conditions. Such an approach is equivalent to the range or scope of a theory in scientific discourse.

Statements which explain the conditions in which a concept or proposition may be validly applied are metastatements, statements about statements. This approach to meaning and truth implies that all concepts or theory refer obliquely rather than directly to the "real world" of empirically identifiable objects and events. A particular concept can only refer indirectly to the "real world" because its meaning--and therefore valid application--is always bound by its relationship to other concepts according to the "bootstrap" principle of mutual self-generation.*

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*Wittgenstein emphasized this point when he spoke of Newtonian mechanics as "'imposing a unified form on our description' of the world rather than 'asserting anything about' the world, (adding that) 'the laws of physics do still speak, however indirectly, about the objects of the world.'" (in Toulmin, 1972, p. 173).

Action

How we understand what someone says and how much we believe it to be true will subsequently influence how we will act, alone and in concert with others. Talking, writing, smiling, running, sitting, laughing, driving, meeting, rebelling are all overt actions in the physical world, and hence available for oneself and others to perceive. With action, then, the basic cycle of the communication process is complete. Furthermore, only through some form of overt action can the results of perceiving, interpreting, understanding, and believing be known to others. Some action--transformation of energy--is required to create information. In this sense, action is information and all information is the result of action. Thus, we have the principle of the unity of action and information.

Action creates a difference open to interpretation within the context of other differences which could have occurred. Thus, information is based on the potential for choice among a set of alternative patterns, each of which has some probability of occurrence greater than 0. Uncertainty is reduced when a decision is made, when one alternative is chosen out of the context of others. Information is defined as a difference in matter-energy which affects uncertainty in a situation where a choice exists among a set of alternatives. The greater the number and variety of concepts available in one's cognitive system, the greater the ability to articulate differences in the environment (Kelly, 1955).

Reduction of uncertainty at the physical level of human information processing, however, has nothing to do with meaning, which occurs at a higher level of abstraction. Confusion about this distinction is common in most discussions of information theory. The distinction between the physical and the semantic levels of information processing means that a reduction and an increase in uncertainty can occur simultaneously, but at different levels of information processing. Thus, interpreting a particular pattern that one perceives as the word for "rebellion" may reduce one's uncertainty about which word has occurred (physical level of reality), but may at the same time create uncertainty about what that particular use of the word "rebellion" means (psychological level of reality). Meaning requires understanding at a higher level of decision making.

COMMUNICATION AND CONVERGENCE

Communication is a natural part of life. Like walking, we are able to do it without paying too much attention to the complex process which

makes it possible. Only when the process fails or breaks down do we realize how much effort is actually required.

All symbolic models simplify what they represent, but most of the existing models of human communication tend to oversimplify the process to the extent of becoming misleading. The use of "coding" and "encoding," for example, with message and information processing makes it easy to overlook the important distinction between interpretation and understanding, as well as the relational aspects of mutual understanding.* On the other hand, by attempting to integrate the principles of information theory and meaning we run the risk of creating a model that is too complex to be useful. To avoid this possibility we have created a series of diagrams which simplifies as well as summarizes the model described above.

The Basic Components of Human Communication

The diagram shown in Figure 5 shows the relationships among the basic components of the communication process. The principle of the unity of information and action is indicated by the bold lines. Through this relationship the cycle of communication is complete: all information is a consequence (or physical trace) of action, and through the various stages of human information processing action may become the consequence of information. There is a similar unity underlying the relationship among all of the basic components of the model. There is no beginning or end; there is only the mutually defining relationship among the parts which gives meaning to the whole structure.

The distinction among the components is necessary for purposes of discussion, but should not obscure the underlying unity, nor the nature of communication as a process. Interpretation, for example, involves the application of concepts to decide what information means. But how can this be done without some prior understanding of the situation? Understanding, however, involves the inquiry and search for a deeper, richer significance of one's interpretations through an examination of the implications within a wider context. Yet, interpreting a piece of information may radically alter one's understanding, perhaps forcing additional reinterpretations. To believe that a statement is valid requires some minimal level of understanding, even if in error or inappropriate. Yet, what one already believes to be the case certainly affects how one arrives at an understanding, even what one perceives.

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*This is one of the important distinctions in the field of hermeneutics, the study of meaning and interpretation (Palmer, 1969).

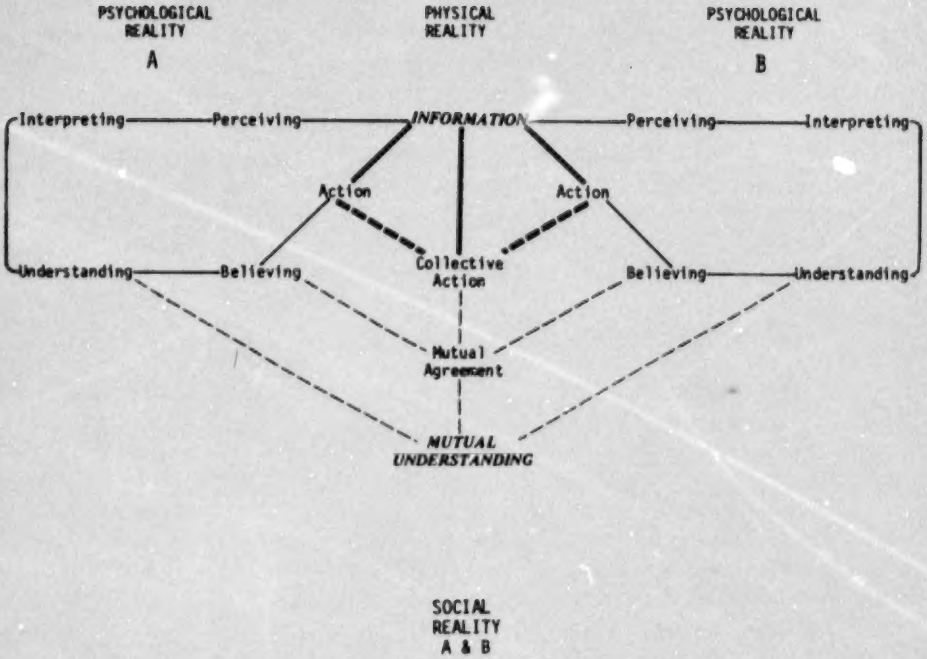

FIGURE 5.
Basic Components of the Convergence Model of Communication

Human emotion, treated as something of a mystery by many social scientists, may be considered within the proposed model as an internal, physiological action, or reaction, which above some threshold level of difference is perceived and accessible for interpretation like any other type of information. The physiological characteristics of all emotional reactions are quite similar forms of stress, and their differentiation and interpretation depend greatly upon the context in which they occur, according to the general principles of meaning discussed above. Emotional reactions are sometimes unpredictable and easily misinterpreted, which accounts for much of the mystery surrounding them.

Collective action is a result of the activities of two or more individuals (A and B), built upon a foundation of mutual agreement and understanding. When two or more individuals believe that the same statements are valid, they become true by consensus, or mutual agreement with some degree of mutual understanding. The rather positive presentation of the model by this choice of terms should not obscure alternative outcomes of the process itself. As in the case of the convergence principle, each component implies that its opposite may also be the case: misperceptions, misinterpretation, misunderstanding and disbelief may reduce mutual understanding and lead to disagreement and that form of collective action referred to as conflict. By simply dichotomizing mutual understanding and agreement, we can conceive of four possible states: (1) mutual understanding with agreement, (2) mutual understanding with disagreement, (3) mutual misunderstanding with agreement, and (4) mutual misunderstanding with disagreement.* Furthermore, each outcome can be conceptualized and measured as a set of two continuous variables.**

The two most important components of the model are emphasized with bold type: **information**, from which the whole model is derived, and **mutual understanding**, the primary purpose of human communication. A simple diagram of the components, useful as it may be, should not be allowed to obscure the process nature of communication, nor the principle of convergence.

A Model of the Convergence Process

Communication is a process in which two or more individuals or groups share information in order to reach a mutual understanding of each other and the world in which they live. A diagram of communication as a process of convergence towards mutual understanding should show mutual understanding as a goal which can be approached, but never perfectly achieved, and the cyclical nature of information sharing over time.

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*McLeod and Chaffee's (1973) coorientation measurement model distinguishes between agreement, understanding, and accuracy. Accuracy, the extent to which one's estimate of another's cognitions matches what the other person actually thinks, is equivalent to mutual understanding in the convergence model.

**Perhaps through a combination of direct magnitude estimates of conceptual differences and metric multidimensional scaling (Woelfel and Danes, 1979).

Mutual understanding may be defined as the combination of each individual's estimate of the other's meaning which overlaps with the other's actual meaning. In other words, mutual understanding is a combination of the accuracy of each individual's estimate of the other's actual meaning. Rommetveit (1968, p. 189) describes this process as "converging projections" of cognitive representations by speaker and listener onto the domain of objects and events in the world.

The overlap of cognitive representations--each individual's own understanding of the situation--is represented by the shaded area in Figure 6. The overlap is never perfect; convergence never complete. The concepts that one has available for understanding are learned through experence. No two persons have ever had identical experiences, hence the conceptual systems which individuals use for understanding can only approximate one another within some level of tolerance.

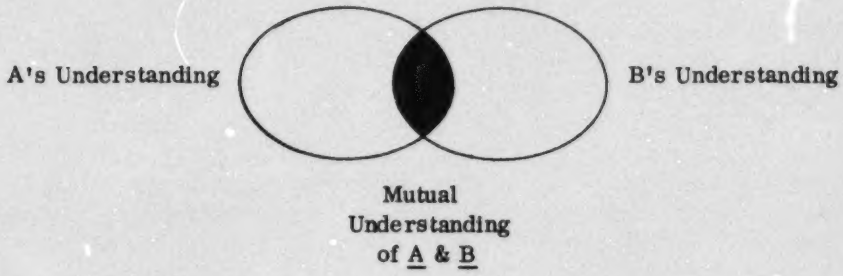

FIGURE 6.
The Convergence of Mutual Understanding

By means of several iterations of cycles of information-exchange, two or more individuals may converge towards a more mutual understanding of each other's meaning, and come within the level of tolerance required for their purpose at hand. One can only know how well someone else understands the situation if the other person also shares information, and vice versa. After several cycles of information-exchange, communication may

shift to a new topic or area of discourse. The model of the communication process shown in Figure 7 reflects the convergent nature of mutual understanding as well as the cyclical nature of information exchange.

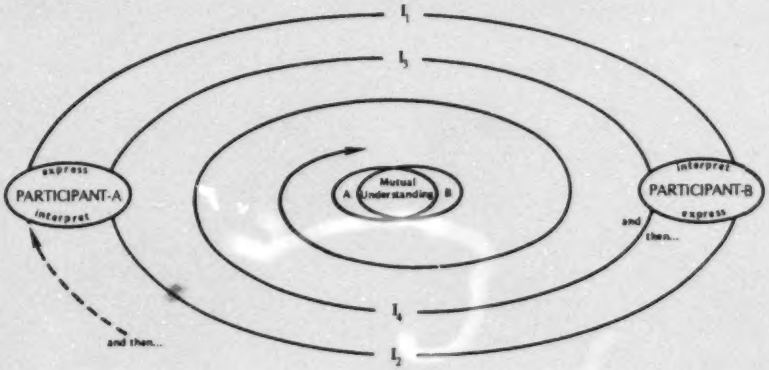

FIGURE 7.
The Convergence Model of Communication
Source: Kincaid and Schramm (1975).

The communication process always begins with "and then . . ." to remind us that something has occurred before we begin to observe the process. Participant A may or may not consider this past before he shares information (I_1) with participant B. B must perceive and then interpret the information which A creates to express his thought, then B may respond by creating information (I_2) to share with A. A interprets this new information and expresses himself again with more information (I_3) about the same topic. B interprets this information, and they continue this process (I_4. . . n) until one or both become satisfied that they have reached a sufficient mutual understanding of one another about the topic for the purpose at hand. Each participant interprets his own information as well, to understand and to find improved ways of expressing himself. Thus there are no arrowheads "to and from" each unit of information. The information is shared by both participants.

As the model implies, the primary purpose or function of the communication process is mutual understanding. The basic means by which this is accomplished is through the creation and sharing of information. What is termed the "purpose at hand" above refers to the other (secondary) purposes which each participant may have for communicating. Convergence (or divergence) towards mutual understanding as a cybernetic process

defines communication and its function in social intercourse. Any other purposes which human beings are capable of imaging and hoping to achieve may also be operating when two or more persons share information. Although these secondary purposes may interfere with mutual understanding, they, and most other forms of collective action, are contingent upon mutual understanding within some level of tolerance. Mutual understanding is the primary function of communication; the secondary purposes are purposes of the participants and, in a sense, may be endless. This important distinction becomes confusing at times because the participants themselves may state that mutual understanding is their purpose.

To converge is to come together to a more common focus, or point of view, where a variety of meanings and points of view are possible. As the model suggests, that point is never reached. Mutual understanding is never perfect; some element of uncertainty and error always remains. The meaning of language is never complete. It undergoes continual development, through the process of communication, as it is used.

The convergence model is based upon some of the fundamental principles of information, cybernetics, meaning, and language combined and articulated in a manner which should make them easier to apply for professionals who use communication in their work as well as those engaged in scientific research on the communication process. The model does make more stringent demands on those who use it. The usual focus on sources as sources and receivers as receivers should be cast aside in favor of a definition of all of the relevant individuals or groups who share information and a gathering of the same information from each one. What is usually called the "message" should not be singled out at the expense of other important information and the wider context in which it is shared. And finally, the model calls for longitudinal research designs and time series analysis so that the process itself comes under analysis and so that rates and directions of change can be studied as well as the relative positions of the participants at just one cross-section of time.

The measurement of each participant's understanding, agreement, and belief demands rather high levels of precision and rigor on the part of the scientist, especially since these must be compared relative to one another rather than with the usual source bias. Fortunately, promising new methods of cognitive measurement based on ratio, direct magnitude estimates of conceptual differences combined with metric multidimensional scaling procedures, have now made it feasible to measure the hypothetical "points of view" mentioned above, compare their degree of convergence in N-dimensional space, and observe their movement over time in a manner

similar to that shown in Figures 1 to 3 (see Woelfel and Danes, 1979; and Gillham and Woelfel, 1977).

As we shall see, some of the ideas expressed in the convergence model have been articulated before in the East as well as in the West. In the East, however, we find a better concept of causality for the study of human communication. The convergence model structures these ideas in a more coherent form, so that they can be more effectively applied in the practice and in the science of communication.

CONVERGENCE EAST AND WEST

The basic idea of convergence was presented almost a century ago by the American philosopher Charles Sanders Peirce. His inquiry into the nature of signs and meaning led him to the inherent vagueness of language as it is actually used. According to Peirce, a sign is objectively vague if it requires some additional sign or experience to delimit its meaning. He reached the astonishing conclusion that "no concept, not even those of mathematics, is absolutely precise [because] . . . no man's interpretation of words is based on exactly the same experience as any other man's" (Gallie, 1966, p. 175). This led to the point of view that every symbol, word, sentence, even scientific formula must essentially be developed in order to fulfill their proper function of communicating intelligent thought.

The interpretation of any sign is accomplished in terms of, or by means of "some further sign, which may confirm, amplify, qualify, or correct the original sign [and] develop it" (Gallie, 1966, p. 46). The meaning of any utterance is revealed by the reply that it evokes which needs a return reply to interpret it, in potentially endless sequence. Recognition of this aspect of communication means that the correct use and understanding of any sign are always a matter of degree. Peirce's insights capture the basic principle underlying the convergence model as well as the process represented by the diagram.

In classical Chinese philosophy, the work which most closely approximates the principles of the convergence model comes from the Taoists, especially Chuang Tzu, about whom little is known personally. He lived during the same period as Mencius, approximately between 399 to 295 B.C., but there is no evidence that they knew each other, probably because of geographical separation (Chan, 1963, p. 179). He was once a minor government official and supposedly declined an offer to become prime minister in order to retain his freedom. Much of his philosophy runs counter to the

teachings of Confucius and other schools of thought, especially the dogmatic acceptance and application of those teachings. His work eventually had a substantial impact on Buddhism, especially the development of the Zen School. Chuang Tzu is best known perhaps for his "revolt against traditionalism and conventional standards, his poetic mysticism, his subtle individualism, his insight into human nature, his profound interest in how to live and how to respond to all things" (Chan, 1963, p. 179).

"The Identity of Contraries," chapter two of Chuang Tzu's collected work, makes a significant contribution to the philosophy of knowledge, language, and communication. It may be read as a ridicule of the endless and futile controversy between the followers of the Confucianist and Maoist school of thought, "each school regarding as wrong what the other considers as right" (Chan, p. 182). More generally, it teaches the futility of using rhetoric and debate as a means of establishing the "truth."

It is speech itself that makes Chuang Tzu skeptical:

> . . . how can Tao be so obscured that we speak of it as true and false? And how can speech be so obscured that it admits the idea of contraries? . . . How can speech exist and yet be impossible? (Giles, 1926, p. 16).

As we have pointed out above, categorical language is reductionistic and divisive rather than holistic and synthetic. We see, for example, the boundaries between a tree and the soil in which it is implanted.* This arbitrary separation makes it difficult to understand how each one came to be. Rather than suggest that the soil is produced by the tree and that the tree is produced from the soil, an apparent contradiction, it is easier initially to posit some external, third party, God, which makes both at the same time.

The Tao, on the other hand, produces by "not-making" (wu-wei). This follows from Alan Watts' (1957, p. 16) interpretation: "For things made are separate parts put together, like machines, or things fashioned from without inwards, like sculptures. Whereas things grown divide themselves into parts from within outwards." Knowing that the world

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*Notice that the language itself ("in which it is implanted") separates and distinguishes the tree from the soil and, of course, the air which "surrounds it."

works mainly according to the principle of growth, the Taoist would not ask how it was made. A universe which grows utterly excludes the possibility of knowing how it grows; it operates according to the Tao's principle of spontaneity.

The Western concept of the producing agent is partly responsible for our thinking about causation in general, which has had a strong influence on our preconceptions about how communication has causal effects on receivers.* In his already classic work on Science and Civilization in China (1956, p. 199), Joseph Needham relates this in part to differences in the Chinese language as well as thought. The subject-predicate proposition and the Aristotelian identity-difference logic are less easily expressed in Chinese.

Chinese language and thinking lends itself more readily to a concept of mutual causation based on relationship, and to a form of logic which is dialectical and correlative. The concepts of becoming (wei) and relation (lien) are more fundamental to Chinese thought than substance, as the following verse from Lao Tzu's Tao Te Ching suggests (Needham, 1956, p. 199):

> Existence and non-existence mutually generate each other, the difficult and the easy complete each other, the long and the short demonstrate each other, high and low explain each other, instrument and voice harmonize with each other, before and after follow each other.**

The meaning of a term is completed only by its relationship to its opposite, and "things" are conceptualized as becoming, through a process of mutual production (fang-sheng, simultaneous coexistence). "Where Western minds asked 'what essentially is it?', Chinese minds asked 'how is it related to its beginnings, functions, and endings with everything else, and how ought we to react to it?'" (Needham, 1956, p. 200).

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*See the discussion above on the role of mechanistic causation in linear models of communication.

**Lau's (1963, p. 58) translation of this verse is accompanied by a footnote which explains "before and after following one another" by an analogy to a ring or circle in which any point is both before and after any other point depending upon the arbitrary starting point. In Chapter 40, Lao Tzu states that "returning [turning back] is the characteristic movement of the Tao" (Needham, 1956, p. 76), which is well represented by the Chinese symbol for Yin and Yang.

Whether or not one would accept a relational or associational concept of causality for physical reality, it does apply more adequately to information processing, language, and meaning than the mechanistic concept of causality. Contemporary communication theory would benefit greatly from the adoption of a more Eastern concept of causality. To do so would require giving up the mechanistic, unidirectional approach to the study of effects, and replacing it with an approach based on change in the mutual associations or relationships among the concepts of those who share information.

If the relationship among concepts can be defined in terms of their difference and similarity, distance and closeness, then multidimensional scaling methods would provide at least one appropriate procedure for measuring such change. Multidimensional scaling (Torgerson, 1958) differs greatly from the conventional procedures for unidimensional scaling. The respondent scales the objects of study (word-concepts), rather than scaling himself on the conceptual dimensions supplied by the researcher. Since the communication process brings words (and indirectly, concepts), into varying degrees of association, we would expect changes to result in the mutual relationship among the relevant concepts of the individuals or groups of individuals who participate. New methods of metric multidimensional scaling can now be used to measure these changes over time and to compare the degree of convergence of two or more groups' cognitive representations. *

To observe the actual changes in the conceptual relationships (differences and similarities) of each participant's cognitive representation requires a much higher than categorical level of measurement. The difficulty with measuring change, as opposed to position, is that it is so hard to know when the boundaries of one category have been passed and the next category entered. "Such insensible transitions have therefore always been the thorn in the flesh of formal logic, as we can see by comparing the Procrustean beds of Victorian science with the paradoxical yet powerful and mathematically expressible conceptions of science today, or going further back, the flexibility of 17th-century science with the rigid

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*The Galileo^{TM} system consists of a ratio model measurement and a computer program for metric multidimensional scaling, which is capable of comparing two or more r-dimensional spaces by means of a least-squares rotation routine (Gillham and Woelfel, 1977; Woelfel and Danes, 1979).

Aristotelian formalism of the Middle Ages from which it had successfully struggled to free itself" (Needham, 1956, p. 76).

For the field of communication to develop as a science, theories are required to resolve the contradictions and paradoxical problems of change, and they must be accompanied by models and levels of measurement which permit the more powerful expressions of mathematics used by other sciences.

The tools of modern science and mathematics were obviously unavailable during the classical period of Chinese philosophy. The problems of change and contradiction were, nonetheless, readily apparent. It is interesting to note that, "The dialectical reconciliation of contradictions in a higher synthesis, which is so often seen in science, appears with much clarity in the Taoist writings, especially in the second chapter of Chuang Tzu" (Needham, 1956, p. 77).

In Taoist thought, contradictions between "this" and "that," "right" and "wrong" cannot be transcended by asking a judge. If the judge agrees with one side or the other, how can he be a fair judge? If he agrees with both sides, how can he judge at all? If the two sides and the judge cannot decide, should they wait for still other opinions? According to Chuang Tzu, waiting for changing opinions is like waiting for nothing. Reconciliation of the contradiction between "right" and "wrong" is reached by transcending artificial distinctions, and by recognizing that there is wrong because of the right, and there is right because of the wrong.

The Tao is hidden when men can understand only one side of a pair of opposites, and concentrate on only a partial aspect of a problem. Clear expression becomes muddled by mere wordplay, by arguing for one side and denying all the rest. According to Chuang Tzu this limitation can only be overcome by freeing oneself from the limitations of the "I," and following the path of intuition which encompasses the "I" and the "Not-I." The wise are thus able to see both sides of every argument, to see that the "this" is the "that" and that the "that" is the "this," that the right is wrong and the wrong is also right. They see that ultimately all sides are reducible to the same thing, unity, once they are related to the "pivot" or "axis" of the Tao:

> When the wise man grasps this pivot, he is in the center of the circle, and there he stands while "Yes" and "No" pursue each other around the circumference. The pivot of Tao passes through the center where all affirmations and denials converge . . . at the

Rapoport (1967, p. 286-287) establishes a formal set of rules or procedures for proving one's level of empathy with another, and for reducing the threat and rigidity of each party's subjective viewpoint. Conveying to the opponent that he has been heard and understood can be accomplished satisfactorily only if one states the opponent's position as clearly and eloquently as possible. This requires effective listening and understanding. Delineating the region of validity of the opponent's stand can be done by stating the context and conditions under which the opponent's position would be accepted as valid. Finding where the opponent's initially "wrong" position is "right" reduces threat, yet still implies how it may be wrong. This second rule specifies what amounts to the "seeing the right of wrong and the wrong of right" recommended by Chuang Tzu. Inducing the assumption of similarity is a result of the first two rules. By demonstrating that the other can be believed and trusted, one may show that he also can be believed and trusted, and induce the other to follow the same rules of empathy.

The result of this effort is better mutual understanding of one another's point of view; it may not be full agreement, but is at least a clearer understanding of where and how each position is similar and different. If this approach is perceived by either party as a strategy for winning, it will be self-defeating and invite a defensive counterstrategy.

There are many important differences between the East and the West, and to some observers the two may never meet. Certainly, we can find disagreement in both the East and the West about the convergence model of communication and how communication works in general. We have demonstrated, however, that in certain respects many of the basic concepts of classical China are similar and highly relevant to contemporary problems of communication theory. This convergence is not accidental. Many of the conclusions reached in the East and the West have been developed from the same premises regarding the nature of language, knowledge, and information.

It is tempting to conclude that we may have just "reinvented the wheel." This point of view, as we have learned, rests on a view of knowledge as a "something" built by someone from the outside in, rather than as a process of growth or becoming from the inside out. We have not so much built an old wheel as we are part of an old wheel, where every ending comes both before and after a new beginning.

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still-point from which all movements and oppositions can be seen in their right relationship.* (Merton, 1965, p. 43).

Is this the same hypothetical point of convergence represented in the convergence model of communication by the overlapping regions of mutual understanding? In our discussion of the model, we posited that this exact point of perfect mutual understanding can never be reached--only approximated--by communication because of the inherent uncertainty of information and language. The Taoist may reach this point, however, by discarding the artificial distinctions imposed with words and using intuitions and the "light of Nature."

In another passage, Chuang Tzu describes reaching this point by aiming at the "light which comes out of darkness." The sage ". . . does not view things as apprehended by himself, subjectively, but transfers himself into the position of the things viewed. This is called using the light" (Giles, 1926, p. 22, emphasis added).

The use of intuition and seeing from the position of the things viewed may seem strange to those from the West, but the idea of seeing things from the point of view of the other should not. The concept of empathy is based on the principle of giving up one's own subjective viewpoint and assuming the point of view of the other. How can this be done without some element of intuition?

Empathy is the basic element of nondirective psychotherapy and psychology developed by Carl Rogers (1961) and his students. Through his own work, Rogers discovered that the only learning which significantly influences behavior is self-discovered learning, and the "truth that has been personally appropriated and assimilated in experience, cannot be directly communicated to another" (Rogers, 1961, p. 276, emphasis added).

Rapoport (1967) generalized the Rogerian approach to situations of controversy and debate. Attempts to sell one's point of view very often only make the other more rigid and resistant to change, not so much from satisfaction as from the necessity of defending oneself against the threat of other images. A stalemate can be overcome if one or both parties says in effect, "I understand how you feel," and then proves to the other's satisfaction that he really does.

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*According to Legge's translation, opposing sides are judged " . . . from the 'axis' of the Tao, around which all Nature moves" (Needham, 1956, p. 77).